ADMINISTRATIVE INFORMATION

1. **Project Name:** Advanced Thermoelectric Materials for Efficient Waste Heat Recovery in Process Industries

2. **Lead Organization(s):**
PPG Industries, Inc.
Glass Technology Center
P.O. Box 11472
Pittsburgh, PA 15238-0472

Pacific Northwest National Laboratory (PNNL)
P.O. Box 999
Richland, WA 99352

3. **Principal Investigator:**
Peter Martin, PNNL
509 375-2076
peter.martin@pnl.gov

4. **Project Partners:**
Michigan Technological University, John Johnson,
906 487-2576, jjohnson@mtu.edu
Visteon Automotive Systems, Edward Boulus
Owens-Illinois,
Leadbetter & Sons, Inc., Bart Marvin
Alcoa, David R. Williams
724 337 5991, david.r.williams@alcoa.com

5. **Date Project Initiated:** December 30, 2003

6. **Expected Completion Date:** March 30, 2007

PROJECT RATIONALE AND STRATEGY

7. **Project Objective:** The project will investigate, develop and deploy high efficiency thermoelectric energy conversion technology to recover waste energy from exhaust gas in process industries. The overall goal is to demonstrate that waste heat from a glass production process can be utilized to generate electrical power at an efficiency greater then 20%.

8. **Technical Barrier(s) Being Addressed:** The technical barriers are associated with lack of robust, affordable materials for thermoelectric devices and the scale up and transfer of thin film thermoelectric technology from the laboratory to an actual use environment. This includes the development of thin film thermoelectric materials and efforts to scale up the process for depositing thin film structures. In addition, the integration of the thermoelectric generator with a waste heat system will be a challenge. Other barriers include emissions from the process that may result in the degradation of the thermoelectric material.

9. **Project Pathway:** New technology in thermoelectric materials will be developed and combined with advanced capabilities in modeling to design and create thermoelectric generators to recover electrical power from waste heat. This will be accomplished by the development of thin film thermoelectric materials by a sputter deposition process to create superlattice films, fabrication and bench scale testing of thermoelectric generators, modeling of heat transfer processes to provide guidance for

system integration, design of prototype thermoelectric generators for implementation in waste heat stacks, and a preliminary economic analysis for implementing the technology.

10. **Critical Technical Metrics:** Prior to 1990, the baseline for thermoelectric conversion efficiency was in the 6 to 8% range. The target efficiency for a bench scale demonstration of electrical power production using thermoelectric materials is 40%. The target efficiency for a prototype system retrofitted to an existing facility is 20%.

PROJECT PLANS AND PROGRESS

11. **Past Accomplishments:** Not applicable, projects initiated in FY04.

12. **Future Plans:**

    1. Design a thermoelectric energy conversion system accounting for waste heat collection, thermal conductance and heat transfer. The thermoelectric elements will consist of thin films of material with areas and thicknesses selected to obtain maximum temperature difference across the elements and maximum thermal energy conversion efficiency. Planned Completion Date 3/30/2005
    2. Perform a preliminary economic analysis to determine the potential cost benefit of the electrical power produced. Costs associated with retrofitting industrial production facilities and thermoelectric module fabrication will be considered. Planned Completion Date 3/30/2005
    3. Fabricate a prototype thermoelectric generator based on current PNNL materials and bench test it under simulated use conditions. Planned Completion Date 6/30/2005
    4. Fabricate and characterize several material systems for advanced large scale thermoelectric applications. One system will be the superlattice films based on Si and SiGe that PNNL is currently investigating. The two other material systems that will be considered are superlatices based on $B_4C/B_{12}C$ and skutterudites such as $LaFe_3CoSb_{12}$. Planned Completion Date 3/30/2006
    5. Scale up the deposition process for producing these materials. Planned Completion Date 3/30/2006
    6. Optimize the combustion emissions for energy conversion to reduce the potentially detrimental build up of particulates from the exhaust stream on the thermoelectric material. Planned Completion Date 6/30/2006
    7. Demonstrate and test the prototype generator using waste heat at an actual facility. Planned Completion Date 3/30/2007

13. **Project Changes:** None.

14. **Commercialization Potential, Plans, and Activities:**
    The end-use application for the technology developed during this project is the conversion of waste heat from industrial stacks and flues to electrical power. The anticipated product of this research is a thermoelectric generator. Current plans are to install the initial systems in furnaces at glass plants. The technology can be disseminated throughout the glass industry by collaborators on this project, that include three of the world's largest suppliers of flat, automotive, fiber, and container glass plus a supplier of industrial furnaces. The furnace manufacturer will also be able to apply the thermoelectric recovery technology to other energy intensive industries, such as steel, aluminum, and chemicals.

15. **Patents, Publications, Presentations:** None to date.